

Modern methods for rainbow trout production

A Time for Trout



Prof. Andrzej Cierieszko studies the biochemistry and physiology of sperm in vertebrates. He takes an interest in aquaculture and the preservation of fauna biodiversity

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Trout breeding has emerged as a spectacular success in Poland. Advanced technologies have made it possible to alter the gender of fish and to establish special all-female schools

For many years now, the whole world has seen a drastic drop in fish catches and the gradual disappearance of many species.

This significant downturn in natural sea fish populations is being caused by excessive fishing efforts, encroachment on natural spawning grounds, and pollution in the marine environment. The only way to satisfy the growing demand for fish as food is to develop aquaculture, i.e. techniques for the intensive breeding of water organisms.

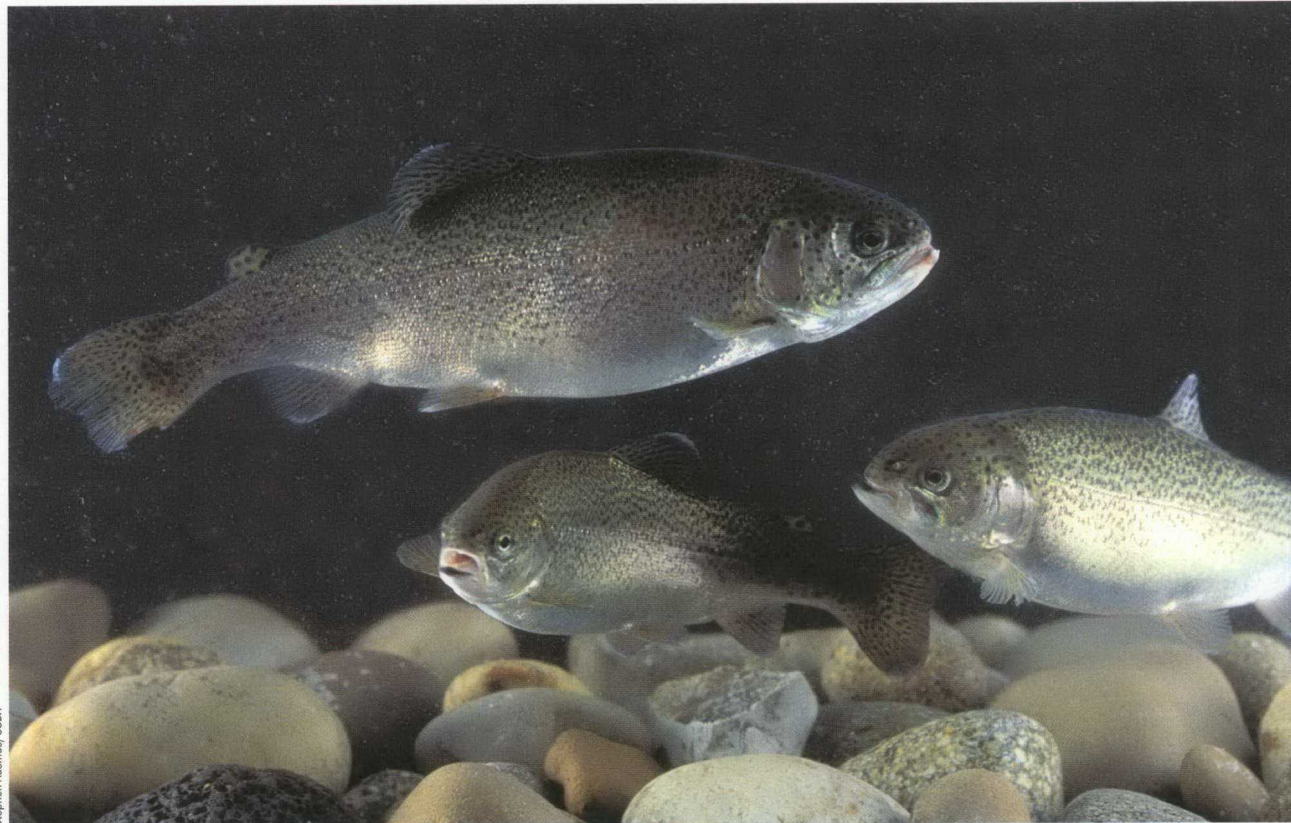
Threatening the king

Fortunately, Poland has a long tradition of successful fish breeding, stretching as far back as the Middle Ages. Yet while rainbow trout farming was historically of small economic significance in Poland, it has been taking great strides forward in recent decades. Annual trout production stood at less than 500 tons in the 1970s, but has now risen to some 15,000 tons, a 30-fold increase. The same period of time has likewise seen great advancement in pro-

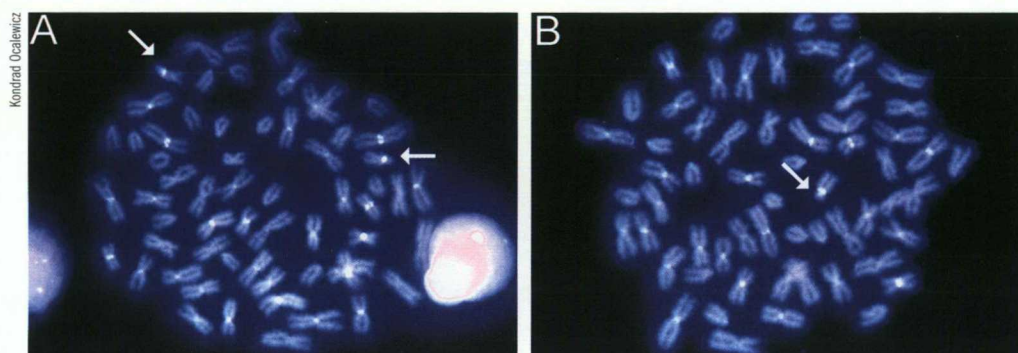
In the coming years, the trout (with annual production now at 15,000 tons) will most likely overtake what was once the unquestioned "king" of Poland's fish hatcheries: the carp



Dr. Konrad Ocalewicz researches the genetic determination of gender in fish, sex differentiation of chromosomes, and disorders in chromosome structure



Stephen Ausmus / USDA



Identifying the gender chromosomes in trout is very difficult, and only possible in certain populations. Here, arrows show the X chromosome in cells of female (A) and male (B) rainbow trout of the Rutki strain

duction techniques, from primitive methods using wet feeds to production technologies using high-calorie, ecological, concentrated dry feeds, plus sedimentation ponds and machinery to reduce the organic compound content in discharged water (after the fish are rounded up). In the coming years, the trout will most likely dethrone what was once the unquestioned king of Poland's fish hatcheries, the carp, whose annual production stands at 22,000 tons.

New challenges

Modern trout production is based on intensive breeding technologies, aimed at obtaining young offspring growing at a fast pace. Experience has shown that rapid fish growth can be achieved by breeding monosex fish stocks. The individuals in such all-female or all-male fish strains grow at a similar pace, and cases of aggressive behavior are rarer. Farmers have therefore become increasingly interested in recent years in seeking methods of establishing such monosex fish stocks.

The choice of which fish gender is better to farm depends on many factors, such as growth rate, the onset of sexual maturity, and the quality of meat from males and females. In the case of trout, the females turn out to be more favorable for breeding, since they mature later than males and thus their growth period is longer. Female trout are also more profitable to raise because feed chiefly goes to increase their own muscle mass, rather than to grow and develop their reproductive system (gonads and gametes), and the meat obtained from females is moreover better for consumption – customers find its color more attractive. All-female fry is thus more economical to raise than balanced-gender fry. The use of single-gen-

der, all-female fry is already a widespread practice in rainbow trout farming in western countries like the UK. In Poland, spawn of this sort is used to a very limited extent (some 2–3%), although imports are rising consistently.

Indirect use of hormones

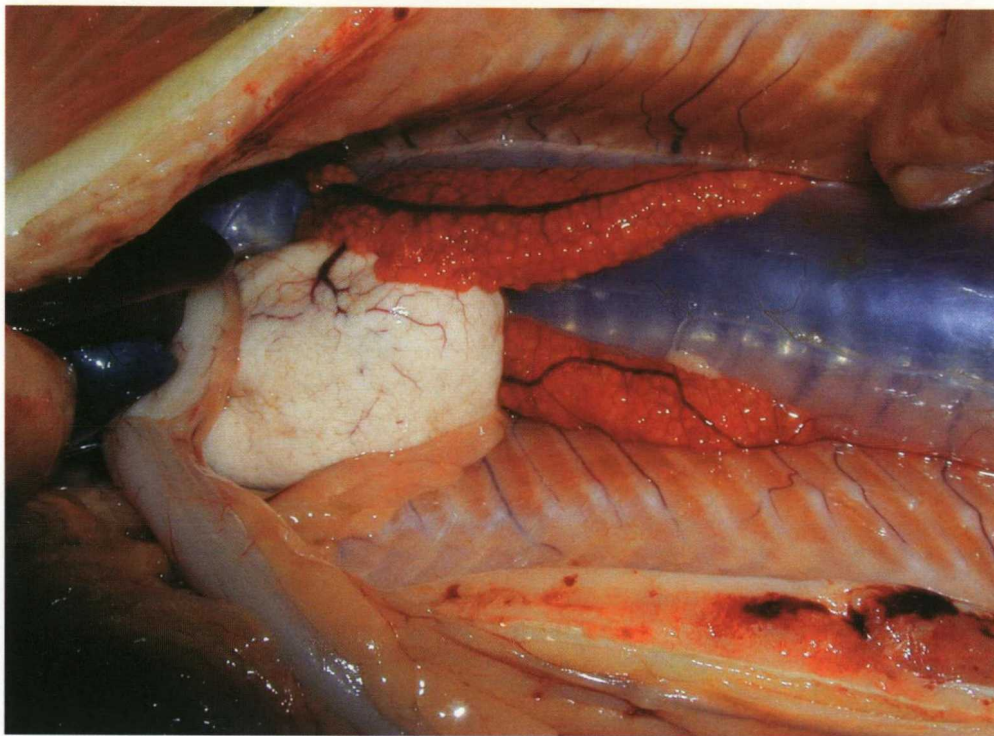
Research into the genetic basis of gender determination in fish from the trout family shows that rainbow trout females (like females of mammal species) develop from embryos containing two X chromosomes in their cells, while males develop from cells containing one X and one Y chromosome. A practical method used to obtain all-female fry initially involves the “masculinization” of a set of females, a processes that uses hormones to alter their phenotypic gender – possible because the basis of gender in fish is labile (prone to change). Called “neomales,” the fish so obtained possess all male traits while remaining female in the genetic sense (carrying two X chromosomes) – they therefore produce sperm containing only X chromosomes, which can subsequently fertilize the spawn of a normal female to produce exclusively female offspring. This method of obtaining all-female fry is called “indirect feminization,” because hormones are only used indirectly to produce neomales, rather than directly to produce female specimens. Masculinized females most frequently lack sperm ducts and often do not develop a second testis. Inter-sex specimens are also frequently observed, with an “intermediate” gender state due to incomplete gender reversal.

Boy or girl?

Verifying the effectiveness of biotechnological techniques for producing monosex

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Masculinized females (called "neomales") are genetically female fish that have become male under the influence of hormones. Spawn fertilized by semen from such neomales gives rise to exclusively female offspring, later growing into single-sex schools that are useful in fish farming. Sometimes the gender reversal in neomales is incomplete and they may combine traits of both genders - here, a white testis can be seen alongside paired orange-colored ovaries



Wiesław "Miska" Demianowicz

fish strains requires methods for quickly and accurately identifying fish gender. One such method involves seeking genetic markers whose presence in a sample cells would provide an unequivocal indication of gender. Unfortunately, this method proves to be difficult to apply to the rainbow trout because only certain small populations have distinguishable gender chromosomes. In these cases, females have two identical sex chromosomes (genotype XX), while in males one of these chromosomes is shorter (genotype XY). A diagnostic test involving the identification of X chromosomes in fish cells from such populations was developed and tested in practice at the Department of Ichthyology of the University of Warmia and Mazury (UWM) in Olsztyn.

Difficulties encountered in genetic gender identification for rainbow trout from other populations have led researchers to begin to seek other markers, e.g. DNA sequences characteristic for only the males of the species, based on which diagnostic tests can be designed.

Healthy food

Another hurdle faced by the sector is that the wider public still needs to be persuaded about the nutritious value and

benefits of eating fish. The unsaturated fatty acids contained in fish fat offer the best prevention for heart disease. These acids work like medicinal drugs: like aspirin, they reduce blood clotting, like heart medications they reduce the risk of heart arrhythmia, and like statin they raise the level of so-called "good" cholesterol while at the same time eliminating "bad" cholesterol, lowering the level of triglycerides. Despite these facts, fish consumption in Poland is still very low (only 6-7 kg per individual per year), and should be boosted. The production of health-conducive foodstuffs was listed among the priorities of the National Framework Program put forward by the Ministry of Science and Information Society Technologies.

High production standards

Trout breeding represents an important and desired element of the food production sector, in terms of both social impact and advanced production technologies. Some 150 Polish trout farms now provide high-quality products, which are to a large degree subsequently exported by fish processing facilities. These days, however, breeding farms are increasingly processing their own products, as well as organizing recreational

fishing events and investing in gastronomic and hotel infrastructure to boost their own sales – all such measures help create jobs in regions of unemployment. Rainbow trout exports are continually on the rise, and in 2005 nearly 40% of all the trout raised in Poland were sold abroad. The industry needs to continue to implement high standards, in terms of both environmental norms and product quality. Trout farmers are particularly well suited to tackle such challenges, as most of them have graduated from an institution of higher education. This fact has enabled trout farmers to avoid suffering adverse consequences during Poland's emergence from the Communist era and following EU accession.

Joining forces to promote the trout

With the aim of further assisting Poland's buoyant trout production sector, several leading Polish research teams have joined forces to develop a research project to comprehensively study the reproduction of masculinized females. The objectives include identifying the endocrinological (hormonal) basis of masculinization (Prof. M. Sokołowska-Mikołajczyk, Agricultural University, Kraków), characterizing the sperm of masculinized females (Prof. A. Ciereszko, PAN Institute of Animal Reproduction and Food Research, Olsztyn), genetic diagnostics of gender (Dr. K. Ocalewicz, UWM, Olsztyn), developing sperm storage techniques (Prof. J. Glogowski, PAN Institute of Animal Reproduction and Food Research, Olsztyn) and developing technologies for generating all-female populations (Dr. S. Dobosz, Dr. H. Kuźmiński, Inland Fisheries Institute, Olsztyn). The project forms part of a larger project, "New Methods of Perfecting Reproductive Processes – Causes and Prevention of Human and Animal Infertility," coordinated by Prof. Jerzy Strzeżek from UWM. At this project's core are efforts to develop and implement technology to produce all-female spawn. The overall research objective envisions that the results so obtained will help boost the effectiveness of Polish trout farming.

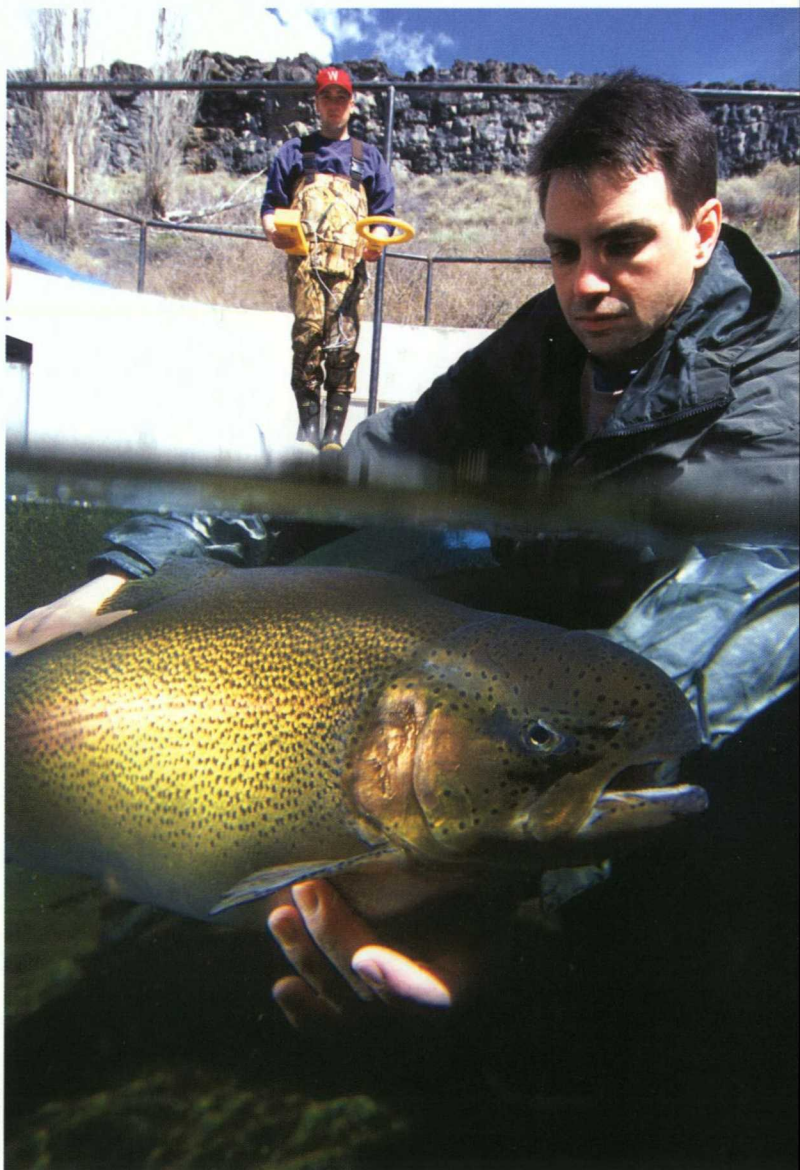
Trout production in Poland is a sector mostly dominated by small and medium-sized enterprises, which do not have the

funding to finance research themselves. The planned project should give a boost to their ability to implement new technologies and know-how, and that in turn will help continue the success of Polish trout farming in the long term.

Further reading:

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- Goryczko K. (2005). *Trout, Breeding and Raising - A Breeder's Guide* [in Polish]. IRS.
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■ **Advanced breeding technologies and methods have brought a 30-fold increase in trout production in Poland since the 1970s. Now the buoyant sector is being further boosted by coordinated scientific research**



Stephen Ausmus/USDA